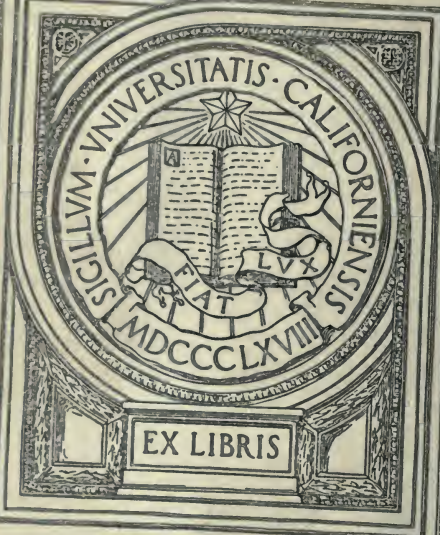
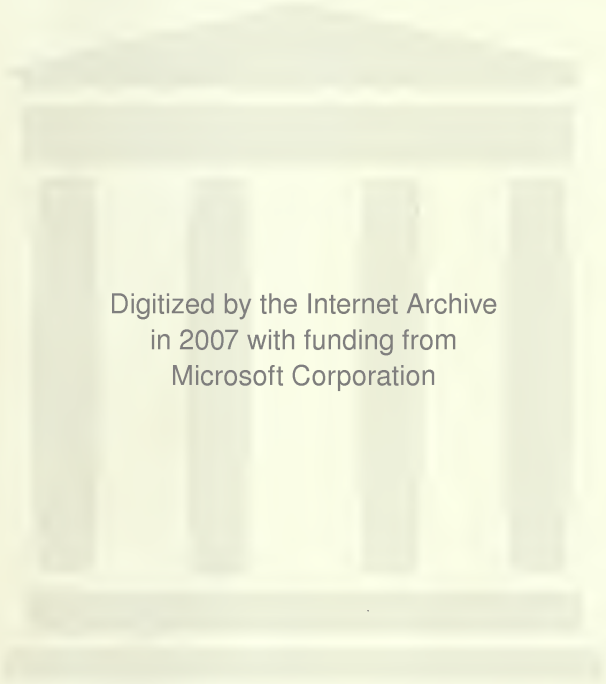
GIFT OF
W. C. Davis





Digitized by the Internet Archive
in 2007 with funding from
Microsoft Corporation

http://www.archive.org/details/reconnaissance00washrich

RECONNAISSANCE.

It is not possible in the limited period allotted to give to the subject of reconnaissance the time which its importance demands. In the cavalry and infantry branch great attention is paid to the subject, and the location of their posts and the frequent practice and other marches afford great opportunities for training, so essential to success.

With us it is different; our stations near cities, our varied drills and duties, lack of marches made under service conditions, all militate against us in reconnaissance work, and my object is, to the best of my abilities, to give you some hints on the subject which may assist you at the outset in your work, until such a time as opportunities for practice may present themselves, and enable you to pursue the subject understandingly.

First of all it is essential that one should be able to read a military map, that is to obtain from it all the information which it is intended to convey. It is quite a simple matter to make use of a map without contours, provided one has had a little practice and is familiar with conventional signs. With contoured maps it is different, especially when the ground is irregular and devoid of strongly marked features.

By a contour I mean the outline in plan of the intersection of an elevation by a horizontal plane.

In this manner of representation there are various terms used which must be understood.

Watershed, meaning the line which embraces the highest element of any feature or chain of hills, for example, the ridge of a roof.

Watercourse, a line which defines the lowest element of a valley, regardless of the presence or absence of a stream.

Col, the neck or saddle that connects adjacent heights. Easily recognized by ranging yourself for one of the heights, for the ground will rise before and behind you and fall off on each side.

Knoll or hillock, a slight eminence.

Plateau, a flat surface on top of a hill.

Spur, a prominent feature projecting from high ground.

Tableland, a high lying level district of country.

Basin, a level surrounded or nearly surrounded by heights.

Undulating, country of alternate gentle elevations and depressions.

Ravine, a narrow valley with steep sides.

Under features, minor features which spring from the main features.

In addition to relative altitudes contours explain the shape and slope of every part, their closeness to each other varying with the slope of the ground. Showing in fact what portion of the ground is favorable for the movements of the various arms of the service, by what roads or paths troops may be moved from one point to another keeping out of view from other points. Where guns may be placed so that their fire may reach other points, where the roads are so steep as to necessitate the presence of extra horses to avoid delay in moving heavy wagons or guns. What sites are most favorable for temporary works, and many other similar points may be determined from the map in advance of an actual occupation by troops.

A contour forming a ring which does not enclose any other may be assumed to represent the top of a hill, or otherwise, it could express only the interior of a crater and in this case it would be well as in all cases of depresaion below the normal contours to mark with a "D."

Again contours can only disappear or run into each other where there is a vertical cliff, and will reappear where the cliff terminates.

1st.—We have the *Horizontal Equivalent* or *H E* always expressed in yards and representing horizontal distance, in which a given difference of level will occur to a given degree of slope.

2nd.—*Vertical Interval*, *V I* expressed in feet and representing the vertical distance between contours.

3rd.—The gradient, which is the slope (*S*) due to the rise or fall occuring in any horizontal distance and is expressed in degrees.

We know that 1° of slope will give a rise or fall of 1′ in every

57.3 feet or 19.1 yards, 57.29 being the natural cotangent of 1 degree, and that at the end of 38.2 yards the difference of elevation will be 2′ and so on.

From this we deduce certain formulae which will solve for us the very conditions of the problem.

Suppose we have given or obtain *H.E.* and *S.* to find *V.I.*

$$\text{We will have } VI = \frac{HE \times S}{19.1 \text{ yds.}}.$$

H E is divided by 19.1 for the quotient so obtained will give the number of feet rise or fall which will occur at a slope of one degree, and similarly *H E* is multiplied by *S* for the reason that the rise or fall will be in proportion of 1 to *S.*

$$HE = \frac{VI \times 19.1}{S},$$

in this case (vertical interval) *V.I.* is multiplied by 19.1 because as previously stated 1′ rise occurs in every 19.1 yards; at 1° therefore if the vertical interval were 20′ it would be $20 \times 19.1 = 382$ yards advance to a rise or fall of 20′ at 1°, and similarly this divided by *S* for the reason that as the slope increased above 1° so the *H. E.* becomes less for the same vertical intervals.

A scale of slopes should be given or made by which the steepness of the ground may be judged.

Let us take a case where we find for instance the scale of the map may be 3″ to the mile and the vertical intervals 10 feet.

$$\text{We have from the formula } HE = \frac{VI \times 19.1}{S},$$

$$\text{for 1° here } HE = \frac{10 \times 19.1}{1} = 191 \text{ yards},$$

$$\text{for 2° here } HE = \frac{10 \times 19.1}{2} = 95.5 \text{ yards},$$

and so on. It only being necessary after obtaining the horizontal equivalent for 1°, viz., 19.1 yards to divide the number by the degree required.

The scale is constructed by drawing a right line and marking off

---

Heights are generally designated in feet and distances in yards in military problems.

from the left from a scale of 3 inches to the mile 191 yards, for 1°, to the right 95.5 yards for 2° and so on for each degree.

In England what is called the normal system is adopted for military sketching, and this is based on 20 feet contours at a scale of 6 inches to the mile, and at all other scales the vertical interval in proportion, so that when the normal scale of horizontal equivalents is used on other plan scales than 6 inches to the mile, the vertical interval between contours will be in inverse ratio, and therefore, that the smaller the scale the larger the vertical interval and *vice versa.*

For example, if the map be made on a scale of 9 inches to the mile the vertical intervals will be $9:6::20:x=13.3$ feet vertical interval, again if the map be on a scale of 3 inches to the mile the vertical interval will be $3:6::20:x=40$ feet. Therefore as we always have 6 and 20 in the 2nd and 3rd term we have the easy rule: to obtain the vertical interval for any scale, we only have to divide 120 by the number of inches to the mile given in order to obtain the vertical interval on the normal scale.

For example, what is normal vertical interval for a scale of 4 in. to the mile $=\frac{120}{4}=30$ feet. The reason for this is apparent, for the contours will always be the same distance apart for the same degree of slope no matter what the scale of the map or the vertical interval, and then the eye will soon get accustomed to the distances apart of the contours for any degree of slope.

Thus 191 yards on a scale of 12 inches to the mile will occupy the same space on the map as 382 yards on a scale of 6 inches to the mile, being doubly the scale though only one-half of the distance, so that the contours are always the same distance apart for the same degree of slope no matter what the scale of the map, provided it is drawn on the normal system. The foregoing formulae for *HE. VI. S.* are approximately correct up to 20° of slope. When the exact *HE* is required, from the result obtained as above subtract the degrees multiplied by .006. Example: Required the exact *HE* for 30 feet at slope of 40° $\frac{57.3}{30}=1.90$ approx. *HE* for 1′ at 40° subtract $40\times.006=.24$ gives us 1.66 exact equivalent for 1 foot at 40°. 1.66×30 gives us the true *HE* for 30′ at 40°.

The main points on which we must be posted in order to benefit by a contoured map are two in number. First the scale of the map or plan and second the vertical interval. The first is always given on the map and usually the vertical intervals are given on the margin, or the contours numbered with the height in feet above assumed level.

There are two methods of describing a slope or the difference of level which occurs in a certain horizontal distance, usually expressed as a fraction, for example $\frac{1}{40}$. $\frac{1}{50}$ or one foot fall or rise in 40 or 50 feet horizontally, or again the slope may be expressed in degrees of elevation or depression above or below the horizontal plane. Just here I may as well explain how to reduce degrees to an equivalent or a gradient and the reverse. In the first case we know that one degree will give a rise or fall of 1 foot in 57.3 feet $\frac{1}{57.3}$, two degrees will give 2 feet rise or fall in same distance $\frac{2}{57.3}$, similarly three degrees will give 3 feet $\frac{3}{57.3}$. Now it is customary in place of 57.3 to substitute 60 so we will have for 1° $\frac{1}{60}$, for 2° $\frac{2}{60}=\frac{1}{30}$, 3° $\frac{3}{60}=\frac{1}{20}$, and so on; in the second case we reduce the gradient to the like degree of slope by dividing 60 by the denominator of the gradient, for example, a gradient of $\frac{1}{10}=\frac{60}{10}=6°$, for $\frac{1}{20}=\frac{60}{20}=3°$, for $\frac{1}{25}=\frac{60}{25}$ $=2.4$ and so on.

We are now ready for our contoured map; when the altitudes are given there is no difficulty otherwise, and the first step is to find the lowest contour, and this will be found at the main stream of running water, then trace the stream upward it will be found that the contours take a re-entering bend, so we know that in looking up a valley the contours are concave; next look for the watershed between water courses and here we find the contours take an outward bend, so remember that looking up a spur the contours are convex.

The next features to be looked for are the cols. In comparing the relative heights either count the contours from the connecting cols or count the numbers from the intervening watercourse, remembering that the number is not number of contour lines but of intervals between them, so that the first contour must be called 0 and not 1; the difference of level is then found by multiplying the vertical interval between the contours by their number.

The question of visibility of one point on a hill to another depends on the general concavity or convexity of the ground and this is determined as follows: When the fall is steepest at top and more gradual at bottom the contours will be closest together at the top and farthest apart at the bottom, so the general section will be concave and lower parts visible; conversely if more gentle at the top and steeper at the bottom the general section would be convex and consequently invisible.

The above refers to points which can be seen directly, but suppose another hill intervenes the visibility would of course be determined by making a section, but to avoid this we have only to remember that the visibility of points is dependent upon the general concavity or convexity of the ground.

To find the steepest gradient of a road, mark on a piece of paper the distances between the contours that are closest together, apply this to the scale of slopes and read it off. If the map have no scale of slopes it may be done as follows: measure the distance in yards

$$\frac{VI}{\text{No. of yds.} \times 3} = \text{gradient.}$$

Having mastered the above points you are now advanced sufficiently to have given to you a map of a portion of ground, which you may soon be expected to march or manœuver over.

Naturally you would examine the map before going to the ground. The first thing you look for is the scale marked on it, so many inches to the mile; then you determine where the north lies, which of course on ordinary maps will be at the top, then the different boundaries, and knowing the length of your span you can tell about the number of square miles. You need this in order to aid you when you arrive on the ground to identify the most important points, as a railway, or river, or road or prominent heights. This study of the map will come easy, as you know how to recognize the different features and recalling the matters to be especially noted viz., scale, vertical interval (interval normal or not) position of true north, general lay of ground as shown by contours and mastering the prominent features, and then practice is all that is required.

Now let us, having studied our map go upon the ground which it

represents. First of all we must find ourselves, or in other words set the map, that is to lay the map in the same position as the ground it represents, north to the north, thus enabling us to identify on the ground the various features depicted on the map.

If we have not forgotten our compass it is very easy to find the magnetic north, especially on maps where the magnetic north is given; on others where it is not given, it must be laid off with a protractor, making use of the side margins which are always drawn true north and south, and laying off from this an angle equal to the magnetic variation, and then laying the map on the ground, place your magnetic compass upon the line of magnetic north and south as constructed, being careful to see that the north and south line is truly under the centre of the compass. We have now simply to revolve the map until the north point of the needle coincides with the north and south line, the map is then set.

Without a compass there are several ways of setting your map; place yourself on some clearly recognized feature so that some other equally recognizable feature can be seen, then place your ruler on the two places and turn the map until the ruler is directed upon the second feature, or again there may be a portion of road, or railroad, or other artificial feature easily detected on the ground, and in this case we only have to lay the straight edge along the representation of the feature on the map, and then turn the map until it coincides with the same line on the ground.

There is another case that might occur, viz., that you had to find your own place on the map, but owing to the absence of any recognizable feature near you, it is difficult to do so with any accuracy. Again if you have a compass you have an easy problem provided you can recognize any two points on the ground from their representation on the map, for you have only to set your map as already explained, and then say place your ruler on one of the points shown on the map and with this point as a pivot turn the ruler until it is directed to that point on the ground, and then draw a line towards yourself. By a similar operation upon the other point we will get an intersection which will fix your position; or again your position happens to be on a railroad or some feature as before described, it

will be only necessary to fix the representation of one point for the intersection of this line and the line upon which you stand will fix your position.

With no compass set the map as already explained by getting in prolongation of, or between two points recognizable both on map and ground; now select a third point and using the representation of it on the map as a pivot, aim at the third point on the ground and the intersection will be your position. Again if you have a piece of transparent paper mark a point to represent your position, and take sights on these conspicuous objects which you can easily recognize on both map and ground. Rule a line for each of these sights. Now lay your transparent paper on the map and turn it until each of these lines passes to the represented point on the map; when this is done you have simply to prick through the transparent paper at the point first marked, and the hole will mark your position.

Sometimes owing to your attention being otherwise engaged you may have failed to keep your eye on your sketch, and so not be able to find your position on it. In such a case you must roughly estimate your rate of march and thus approximately fix your whereabouts. For example, suppose you were using a map three inches to the mile and that your rate was two miles an hour, and about two hours had elapsed since you last fixed your position, you ought therefore to be about one and one-third inches ahead of your last fixed position; now if you mark that point on the map and pick out some feature as a cross road or stream or cutting you can identify your position. As to measuring distances on maps, of course a protractor with the various scales upon it will afford the most accurate means; for all practical purposes a foot-rule graduated to inches and eighths of inches not only enables us to measure off with sufficient accuracy any distance on the map, be the scale what it may, but also furnishes that very valuable adjunct to map reading, viz., the straight-edge. For example, suppose our map be three inches to the mile, a quarter of an inch will represent 146.6, or say about 150 yards. The map when marching through a country with which we are not familiar should be held so as to correspond with the line of advance, for we will then have the map roughly set by holding it

with the road as represented on the map, agreeing with the line of march, thus enabling us to note with accuracy and verifying on the map all cross roads, bridges and other important features.

There are other methods than that by contours for representing sloping ground, viz., by short strokes called hachures, the thickness and number of which are regulated by a scale of shade according to the degree of slope. These strokes are horizontal and the scale of shade of such a drawing gives the slope of the ground. Then again vertical hachures may be used or shading may be resorted to. A little study and practice will enable us to read any of these methods.

MILITARY RECONNAISSANCE.

Military reconnaissance is the process of seeking and recording all obtainable information, of the disposition, numbers and movements of an enemy, and, also, the nature and resources of the country: special attention being given to communications as showing the facilities for the movements of troops.

Reconnaissance may be divided into the following heads: Road, River, Wood, Railway, Villages, Camping Ground, Bivouac, Mountain, Coast, Defensive position.

With the instruments used in reconnaissance we have all had some little experience. The magnetic compass, the clinometer, aneroid barometer, the plane table may each and all be brought into play. With respect to the compass, I only want to state that we may have sometimes one that is not graduated to degrees, but into points, and in this case it is only necessary to remember that if the work is such as to permit of an approximation of ½ a degree, we have only to divide 360° by the number of points, thirty-two, to find the value of a point to be 11° 15′, half a point 5° 37′ 30″, and a quarter 2° 48′ 45″; or, making use of our allowable approximation of half a degree, we have a point 11°, ½ point 6°, ¼ point 3°.

The error thus created will be small and well within the limits allowable in most reconnaissance work, especially when the forward bearing will rarely exceed a few hundred yards, the lateral error at various distances—the result of incorrect bearing—will be approximately for 1° for length of 100 yards forward bearing 1 yd.; for 200

yds., 2 yds.; 300 yds., 3 yds.; and so on up to 1000 yds., where the error reaches about 11.7 yds., and at one mile 31 yds. For 2° of error, with length of forward bearing of 100 yds., the error for 100 yds. will be 2.2 yds.; for 500 yds., 17 yds.; for 1000 yds.. 35 yds., and for one mile, 62 yds.

I wish just here to call your attention to the Cavalry Sketching Case, a device for use in hasty sketching designed by Col. Richard and improved by Capt. Verner (both of the British Army).

DESCRIPTION OF THE CAVALRY SKETCHING BOARD.

The Cavalry Sketching Case consists essentially of a small drawing board (A, Fig. 1), 2 rollers BB, on either end, revolving in sockets in head-piece CC and foot-piece DD. On these rollers a strip of paper of any required length (usually about 30 inches) is wound and thus stretched across the board A. In the head-piece CC a small magnetic compass is countersunk in a collar in which it can be revolved. On the glass of the compass a fine line is engraved, termed the working meridian.

In order to make the board as complete as possible for all demands and contingencies in ordinary rapid field sketching the following scales are engraved on its face:

1. A scale of inches and tenths of an inch.
2. A scale of inches.
3. A scale of 2 inches to a mile to show 50 yds.
4. A scale of 3 inches to a mile to show 50 yds.
5. A scale of 6 inches to a mile to show 50 yds.
6. A scale of Horizontal Equivalents (HE) for 20′ at 6 inches to a mile.
7. A scale of Horizontal Equivalents (HE) for 30′ at 3 inches to a mile.

In the center of the back a metal pivot is fixed, around which the board may be revolved; to this a leather strap is attached, which latter is being used to secure the board to the left wrist, while working. On the back also attached to the foot-piece is a plumb-bob, held in place and released by a spring, which serves in connection with a semicircular protractor, reading to 1°, fastened to

the back, as a clinometer. The slits of two steel screws on the bottom of the foot-piece serve as sights.

To use the board the "working meridian" is set in the required position by turning the compass box round in its socket. The relative position of the "working meridian" to the board itself having thus been determined, the board is being "set" for sketching by revolving it on its pivot until the "working meridian" coincides with the direction of the magnetic needle (Fig. 6).

For instance, suppose it be required to sketch along a road running east. It is obvious, to get full advantage out of the board, it would be necessary to "set" it so that the length of the paper on it corresponded with the general direction of the road, that is so that the inner edge of the head-piece pointed to the east. This being the case the compass needle would be necessarily at right angles to the road, and it is plain that if the "working meridian" be adjusted in this position and the board turned until the needle coincides with it, it will be truly "set" for sketching along the road in question (Fig. 2).

This adjustment of the meridian had best been done before starting, but it also can be done in the field when opportunity offers.

For the latter process it is necessary to note some well defined line such as a straight bit of road or railway or to observe the direction of any prominent object from the position of the sketcher (both of which points must be recognizable on the map), and to "set" the board in its relative position to the ground by laying the straight edge on the observed line on the map and turnining the latter until the ruler is found to be aligned in the direction of the objects themselves. The working meridian is then set by turning it round until it coincides with the magnetic needle. A good way of setting the working meridian before starting, provided the magnetic north has been given or marked off, is to rule a line indicating the magnetic north, as AB in Fig. 5, and another showing the general direction of the route we wish to follow, as CD in the same figure, which we will call the "line of direction".

The longer graduations on the compass ring, as EE in Fig. 3, being truly parallel to the head and foot-piece, that is to the line of direc-

tion, it will be found convenient to regard those as marking the general line to be followed.

Should the map of the country be available, it is easy to fix the location of cities, villages, roads, railroads and streams on a scale which is susceptible of details, and afterwards to sketch in the ground, when passing over it.

The question then arises is the map to be trusted? In order to settle this question, draw several right lines at random across it, observe what features each line cuts and compare this with what you actually observe on the ground, and this test will decide the availability of the map for use. A sketch may convey almost at a glance a great deal of information, but to avoid the multiplication of conventional signs it is better that a part of the information be given by written matter.

The extent and nature of the details, drawn or written, will depend of course upon the object of the reconnaissance. For example suppose we were reconnoitering for a position for defence, certain details which for this purpose might be of the greatest importance would need a mere indication in a reconnaissance for a route march; and again certain details essential in a road reconnaissance, such as proper watering places for horses, might be wholly irrevelant in reconnoitering for a position for defence; and, still again, in a woody or broken country it would be important to show the exact turns of the road, whereas in an open level country this would be unnecessary, as the whole road would be practically under observation or fire regardless of the turns.

In the beginning it is best to observe and note every detail and to train the eye to judge distances by observing at what distance a spire, a chimney, a tree window, window panes may be seen.

ROAD RECONNAISSANCE.

Sketch. Best to take at first a large scale, as 6 inches to the mile, and afterwards 2 or 3 inches to the mile. Commence at bottom of paper and work up, putting in all you can without overcrowding or confusing; remarks to be made on margin clear of sketch and connected with the object to which they refer by a line.

Detached houses, single trees, large rocks and other peculiar features may serve as guides, and should be put in. Public houses should be shown, and names noted. The ground on each side of the road for about half a mile should also be shown, and it will be advantageous to take occasionally some notable point, at a greater distance and work it in by cross-bearings. Sketch must show the position of steep inclines, up or down must be indicated.

A line may be drawn across at the end of each mile. Fences need not be filled in, but their presence simply noted; all branch roads must be noted, their termini when known being indicated by "from" on the left and "to" on the right. Rivers or streams and all important features to be noted. So much for the indicated. The report, *viz.:* information conveyed by writing. Roadways, general direction, nature hilly or not, average gradient, steepest gradient with exact extent and position, whether the road is metalled or not, condition, proximity of material for repairing, width of carriage way, bridges, fords very fully Depressions, defiles, streets in villages and towns on roads, &c., general nature of country, kind of fences, facilities for moving on different fronts of formation, woods especially near road; anything that may tend to retard the rate of marching, such as steepness, broken places, mud or deep sand, with the approximate delay given. Halting places, with facilities for watering, and places on road where if desirable troops in rear could be passed to the front, camping grounds and bivouacs, extent of same and for what forces. Position and front tenable by an advance or rear guard. Rivers: give breadth, depth, velocity, and means of crossing, lateral communications, draw attention and state condition. Describe railroads and telegraphic lines crossing, or in immediate vicinity. Note position of forges, baker's ovens, wheelwrights, and large houses suitable for hospitals or store houses for perishable supplies. Reconnaissance of rivers frequently present difficulties due to the fact that walking along the banks is impracticable, owing to the presence of walls, tributary streams, &c.: on still water a boat may be used; the general direction may often be traced to a long distance by the eye, even though the water may not be visible, by noting the vegetation and position of bridges.

When the course of the river is in the direction of the line of operation the object of a reconnaissance and report is to show how communications may be kept up on the march or for action by a force moving on both banks; and it is important to report general nature of valley in which the stream lies, whether rocky, swampy, wooded, proximity of heights on both sides, nature of stream, whether navigable or not, and if a tidal stream, rise or fall of same: average breadth, depth, rate of current, liability to freshets, character of bottom. Whether or not the banks are precipitous, and if high or low which bank has the command, banks marshy or the reverse. Give tributaries and islands. Bridges in full detail. Fords and their approaches; ordinary depth and kind of bottom; any other points where the passage of the stream is or may be made practicable for different arms. Kind of boats, ferries; if liable to freeze and at what season and to what extent. Three in. will bear infantry, 5-7 in. cavalry and light artillery. If locks, show dimensions of same and to what extent protected from artillery fire.

In the 2nd case: In addition to the above, note nature of approaches and how by the use of troops or obstacles access by them may be barred. Command and distances from the stream of any height, whether artillery range, inundation. Points on either bank suitable for covering or barring the passage of troops.

The strongest current will be generally found in center of river. To find rapidity of current, place two marks on banks about 50 yds. apart, throw into mid-stream an object which will show as little as possible above the surface so as not to be affected by the wind; note the number of seconds it takes to pass from one mark to the other, the number of yards per minute, or miles per hour. Seven-tenths of the mean number of feet per second equals rapidity in miles per hour.

The fordability of rivers will depend upon depth, rapidity, and nature of bottom. The two latter being favorable, a ford of 4′ 3″ is practicable for cavalry, 3′ 3″ for infantry, and 2′ 6″ for wagons and artillery. Give the exact position of fords, their length, breadth and nature of bottom and any deep holes to be avoided, approaches to same and landing places; liability to deepen through rise of tide or

flood. Always examine ford by crossing yourself. Where neither fords nor permanent bridges exist temporary bridges must be constructed, so a report should be made upon the position most suitable for these. A military bridge is most easily defended when it is out of view of the enemy; or in the re-entering bend of a river, or when the defender's side commands the other and when there is an open space on the enemy's side, so that it is exposed to fire. In any case at the point selected the bank should be firm and approaches sound, not cramped or liable to be flooded, the river narrow and not too deep, and little current; islands may be used to lessen construction.

In case of broad and deep rivers a floating bridge of some kind may be best. Note character of anchorage, up and down if on a tidal stream; if broad and shallow, supports and trestles would rest on bottom, so select spot where bed is sound and even.

If narrow and deep some kind of spar bridge might be necessary, and for this select a place where bank is sound but not rocky.

Ferries, position of, size, number and nature of boats and how propelled: whether horses and wagons can be loaded from banks.

Boats, average size, strength, and condition, available; river steamers or barges, material on hand for rafts; wood yards, &c.

RECONNAISSANCE OF WOOD.

First follow principal roads through wood, then pass round the edge, follow ravines or streams leading into it; note the character of country at entry and exit of roads. What trees and undergrowth, if good for abattis; by what arms passable, &c.; ponds or houses in woods.

RAILWAYS.

See special instruclion for road reconnaissance and, in addition, give sketch on margin with transverse scale exaggerated showing water tanks, crossings, turn tables, switches, sidings, platforms, sheds, store houses and approaches.

Marginal information: Bridges, viaducts are to be reported upon and marginal sketches given, noting points of view from where sketched, and giving proposed method of hasty demolition; note

materials on hand for repairs, if found damaged. Cuttings; note extent and nature of cuttings, embankments, tunnels, &c.

General report: name and general character, whether single or double, straight or otherwise.

Station: general description of entrance and approaches to, and ground available for forming up troops; camp grounds near.

Water and fuel supplies for troops and engines. Platforms, sidings, rolling stock, engines, carriages—giving seating capacity of the latter.

The gauge, weight and description of rail and how laid; greatest incline and smallest radius of curvature. Telegraph and signal system—show station. Amount of coal on hand, workshops for repairs of rolling stock, and depots of material for repairs of line. Indicate suitable points for erecting additional platforms and sidings or ramps for entraining or detraining troops, also switching places on single lines; should two lines cross, state if a train can be switched from one line on to the other. If not, whether facilities exist for making a junction between them, number and direction of junction lines between them, lines whether they go through country from which supplies may be drawn. Note if road bed is suitable for use as a road for marching infantry.

VILLAGES.

A general idea may often be obtained of a village without going inside. Note character of ground all around and especially that near the village; command of surrounding heights; if able to get into the village, note interior open spaces, material of which houses and walls are built and length of same, roofing used, buildings suitable for hospital use, barracks, &c. Position of churches and locate points from which the best view of the surrounding country can be had. Horses and wagons available, bakers, blacksmithing.

The amount of information which you obtain from the outside will give you an idea to what extent an enemy could reconnoiter the village. Note water supply, not only quantity but also quality, especially report if the supply be drawn from a distant source which might be cut by an enemy. Also note if the country is such that by a detour the village may be entirely avoided.

SITES FOR CAMPS.

Use scale of 6″ to the mile, so that spaces alloted to various arms can be shown by rectangles of some size. Describe site with reasons for selecting same, slope of ground, surface and subsoil drainage, distance to market towns, streams, marshes, woods and defiles in vicinity. Roads leading to sites are intercommunication, giving also approaches to water supply. Facilities for obtaining water, fuel, forage and straw. If natural supply of water appears insufficient, give arrangements to improve. If in the vicintty of the enemy, give suitability for and means of defence, sand or gravel; give the driest sites; old camps to be avoided, woods unhealthy because of decaying vegetable matter, slopes should not be too steep; should marshes exist, show best route of crossing. Water best from a running stream with gravel bottom and where same stream is used, take in order from up stream, 1st, drinking water, next water stock, next for bathing and last for washing purposes. A dam will often increase the available water by stowing it up. Springs may be sought for in depressions or where the grass is more than ordinarily green. Water from small ponds or shallow wells should be avoided, especially if near habitations. Be careful about locating camp in bottom of valley, if liable to flood; the higher the site, the more healthy. See that communications are kept free from tents.

MOUNTAINS.

In reporting upon mountains note with exactness all passes, mountain streams, steepest grades, and if avoidable, presence of material for repairs of washouts, etc.

POSITION FOR DEFENSE.

The reconnaissance of a position for defence demands a thorough knowledge of tactics, and I shall point out only such points that may be most pertinent. In the first place, the number of men of the different arms must be given. The position should have sufficient depth for manœuvring and shifting troops from one position of the line to another without confusion; of course if the ground be

such that this can be accomplished out of sight of the enemy it would be of advantage; for though but little protection be offered from distant fire, the advantage will be apparent when at close quarters. The position strongest by nature, requires the smallest number of defenders. Should the ground be broken in front naturally or artificially, it would afford, if not levelled, a cover for the enemy. A good position should show a gentle cleared slope towards the enemy over which he must advance. and likewise command a view of his movements, and not be commanded by any height within range. Woods are dangerous either in the front or on the flanks of positions. The best support for a flank is an impassable marsh or large body of water, and where these do not exist the flanks must be artificially strengthened. There should be artillery position commanding the ground outside of infantry range, over which troops must advance, so as to force the enemy to deploy sooner; and remember the artillery, being only on the defensive, can be posted behind swamps or other impassable objects. A position divided perpendicularly by a stream or deep ravine would be objectionable, as rendering it difficult to keep up communication, and enabling the enemy to concentrate on one or the other side; but should such a condition exist in advance of the line, the disadvantage would be clearly with the enemy.

Farm houses and out-buildings, if constructed of stones, may be converted into strong posts, and so to a greater extent may villages; but the subject will be treated later on, in Fieldworks. Great attention should be paid to the roads through and about the position, with a view to their being rendered impassable to the enemy, if considered essential, and this particularly in the case of bridges or viaducts on line of retreat which could be prepared for demolition and destroyed by the rear guard in case of defeat. The very best line of retreat is from the center of the position, while the worst is one parallel to the front. Natural or artificial obstacles in rear of a position will oftentimes enable the defenders to rally and fight on. Should the intention be to occupy the position for a considerable time, the question of wood and water will form an important one. Report will be made giving the position with all that has been given

before, advantages, disadvantages, country in vicinity, communications, bridges, rivers, woods, fences, obstacles, demolitions, trenches, and other works, showing time, number of men and tools.

SEAPORT OR COAST RECONNAISSANCE.

Let your examination be made with a view to both embarking and disembarking troops. Note protection to transports, bottom as affecting holding on, if harbor is exposed in certain winds, description (topographical) of beach and bordering country within range of artillery, depth of water, piers, landings, amount of *rise of tide*, how close ships can come to cover landing. Can ammunition and guns be landed ordinarily; if not, what arrangements can be made for so doing? Kind and depth of beach at high and low water, whether firm or muddy; note communications and any open space near landing; position of headlands as permitting favorable position for defending harbor. Kind of boats available, back country to be reported upon as before explained, and note particularly any commanding or strong points which dominate the landing points, and what roads are best for advancing upon (*vide* road reconnaissance). Note position of cranes or shears and any other contrivance which will facilitate landing or the reverse; water and general supplies, giving all information obtainable of the resources of the country from a subsistence point of view.

Of the foregoing information all relating to water, winds, tides, &c., can be obtained from the sundry charts or mariners.

DATA AND HINTS.

Slopes of 5° practicable for all arms in all formations.

Slopes of 10° practicable for infantry in close order, with difficulty.

Slopes of 10° practicable for cavalry, can canter down and charge up a short distance.

Slopes of 10°, artillery moves with difficulty, the constant fire ceases.

Slopes of 15°, infantry cannot move far with order.

Slopes of 15°, cavalry can trot up a short distance and walk down.

Slopes of 15°, artillery moves with difficulty, fire almost ceases.

Slopes of 20°, infantry cannot move in close order.

Slopes of 20°, cavalry can ascend at a walk and descend obliquely.

Slopes of 25°-30°, infantry, slowly, in extended order.

Slopes of 25°-30°, cavalry, zigzag slowly up and down.

Slopes of 30°-40°, infantry slightly equipped climb slowly, with the aid of hands.

Tracks or foot-paths leading onto the water and houses on other side of stream, without any visible means of communication between them, often indicate the existence of a ford; a mud or sand ford does not last.

When infantry is marching the dust is generally low and thick; with cavalry the dust is higher, upper portion thinner and rapidly disappearing; artillery and wagon trains raise clouds of dust unequal in height and disconnected.

Currents: 1 mile an hour, 100 yds. 3′ 24″, sluggish.
2 miles an hour, 100 yds. 1′ 42″, ordinary.
3 miles an hour, 100 yds. 1′ 8″, swift.
4 miles an hour, 100 yds. 0′ 51″, rapid.
6 miles an hour, 100 yds. 0′ 34″, torrent.

Give rate of current in miles per hour, in preference to any above terms.

For floating bridges the surface velocity must be known; for the nature of the bed, the bottom velocity, and for amonnt of discharge, mean velocity, which in most cases is four-fifths of surface velocity.

Allowance of water, about 10 gallons per man and horse.

Discharge of stream should be given in gallons per minute or hour.

One gallon of fresh water weighs 10 lbs. and one cubic foot contains 6¼ gallons.

To find the discharge, multiply surface velocity in feet per minute by the breadth and average depth, both in feet; this gives a very close approximation to the discharge in cubic feet per minute: find number of gallons by multiplying by 6¼; or we can find approximately the number of men and animals a stream will supply by multiplying together velocity in feet per minute, average depth and

breadth and, this product by 900. Should the stream be small build a dam and arrange so as to catch the overflow in a vessel of known capacity—noting time it takes to fill; then, discharge per minute in gallons will be found by multiplying the quotient, obtained by dividing contents of vessel by the time of filling in seconds, by .22.

To find number of tons in a rectangular stack of hay or straw multiply height, length and breadth in yards and divide by 12 for hay and 17 for straw, and here the height is from ground to eaves with the addition of one-third height from eaves to ridge. For circular stack of straw square the quotient obtained by dividing the circumference of the base in yards by 12 and then multiply the height in yards from base to apex.

A box the inside measurement of which is $13''.^3$ gives a bushel, nearly.

About 3 pounds of fuel per man per day is required.

Accommodation on the line of march, 20 men to a small house, others in proportion; large buildings one-fourth area of story in square yards. Room 15′ wide, 1 man per yd.; 15 to 20′, two men per yd.

Hasty demolition may be effected by means of gun powder, gun cotton, crow-bars, &c.

Gun cotton has about four times the power of gun powder, but if the powder be tamped the difference in favor of gun cotton is about 2½ times. By tamping is meant covering with earth so as to confine gases at ignition and hence fully develop their force.

Gun cotton discs weigh 12 oz. In each a hole is bored for the detonator. If a light be applied to gun cotton, it will burn with a yellow flame but will not detonate. The explosive force of wet gun cotton is greater than that of dry, but a small portion of dry must be used as a primer to detonate it. The following precautions in firing gun cotton must be used: primer must be thoroughly dry, the charge in close contact with object to be demolished. The fuze must be inserted well home into the tube detonator and secured there. The detonator must be so far inserted into the charge that the whole of the fulminate in it is in contact with the gun-cotton.

If the bored hole is not large enough for the detonator, do not attempt to force it in, but ream out the hole. Care must be taken that the gun-cotton is not set on fire by a spark from the fuze before it is exploded. To guard against this, cover the charge with a little dirt.

With gun powder the following precautions should be taken: Charge to be in a compact shape for convenience in carrying; should be well tamped whenever practicable, sandbags being carried for the purpose by the men making the demolition; and they must be easily distinguishable from the powder bags. It would be well to put powder in a tarred bag, covered with another tarred one, so as to prevent a spark prematurely igniting the charge. The end of the fuze must reach well into the center of the charge, and care must be taken that it is not disturbed. Each man to have about him the means of igniting the fuze and the number of men should exceed that necessary for the work, to provide for accidents.

With gun cotton. To cut down trees, bore necessary number of holes into the tree at the same height, meeting in center of trunk; place then the gun cotton and explode simultaneously. By fastening a rope to the upper branches and taking a strain on it before firing the tree may be made to fall in any required direction. Charge, 5 to 6 oz. of gun cotton for a tree of 1 foot diameter; for other trees it varies as square of diameter. Thus, for a tree of 3 feet diameter, $3^2 \times 6 = 54$ oz. A tree may be felled by suspending the charge around it, but this requires about 8 times as much.

To blow down a stockade of 12″ timber, allow 3 lbs. of gun cotton to a linear foot.

With gun powder 80 lbs. of untamped or 60 lbs. of tamped will breach a stockade 6′ in width. For palisading 11″ timber allow 4 lbs. of gun cotton.

Wooden bridges apply rule for felling tree, uprights of piers to be attacked. Axes, oil and fire also may be brought into play.

Masonry bridges, attack haunches, thus making the gap wider, but if time be pressing attack crown. In either case a trench is dug down to point of attack, the length being equal to the width of the road, and charge laid in it. With gun cotton over the crown or

haunches the charge will be $\frac{3}{4}t^2 \times l$ if not tamped; if tamped, $\frac{1}{3}t^2 \times l$ will be sufficient. With gun powder, over crown or haunches, $\frac{3}{2}t^2 \times l$, t being thickness of masonry and l width of roadway in feet. Short bridges with series of arches and short thick piers haunches to be attacked; if piers are high and thin attack them. Iron bridges to be destroyed by placing charges under supports. Railways temporarily disabled by removing several rails or cutting same with gun cotton. Charges to be placed against web of rail halfway between sleepers. 8 oz. of gun cotton will blow out about 1 foot of 75 lb. to the yard rail; for heavier rails use 12 oz. or uncouple fish plates and wrench up rail.

To simply disable telegraph lines remove instruments, or scrape wire clean and bind together with fine wire, thus occasioning a troublesome fault.

TEMPORARY BRIDGES.

These three conditions required in a military bridge, rapidity of construction, portability of material and strength to bear a continuous traffic.

There are three types of military bridges.

1st.—Where bottom can be touched throughout.

2nd. —Where no bottom is available, as in the case of a chasm or of broken arches.

3rd.—For deep rivers where floating bridges of pontoons, boats, casks or rafts must be used.

In all military bridges there are certain component parts, viz:

1st.—The piers of supports.

2nd.—The balks or road bearers which extend from pier to pier.

3rd.—Roadway formed of boards termed chess, laid across the balks and secured by side rails or ribands and lashed to the outside balks.

The piers of the different kinds of bridges are formed in various ways; in case of trestle bridges they rest on bottom, in pile bridges they are driven into the bottom, in floating bridges they are composed of floating bodies such as rafts, casks, etc.

A bay is the distance bridged by one set of balks and generally not over 10 or 15 feet in a military bridge.

Camber is the slight rise given the centre of the bridge to allow for any settling, and is generally about one-thirtieth of the span. Roadway should be eight feet in clear, that is between the interior edges of the side rails, for guns, cavalry and infantry. If passages are to be made on the bridge the width must be increased to 16 feet. Approaches to the bridge must be easy. If approached by ramps they should not exceed one in seven and one in ten is much better. Bridges should have a hand rail if practicable, and there should be conspicuously posted the greatest weight permissible upon the bridge. Twigs, straw or dirt thrown on the bridge will greatly lessen the noise and liability of the horses being frightened. Different arms should cross at different times or on different bridges. Infantry must break step and not close up, cavalry as a rule in file and never faster than a walk. If horses are unsteady the artillery must be passed over by hand and same for all wheeled vehicles. No halts must be made if avoidable; if necessary bring the greatest weight midway between two piers. Should bridge sway a halt must be made until swaying ceases. The number of balks will depend upon the weight to be borne, provided always that they must be near enough to give sufficient stiffness to the chess. The balks do not bear each an equal share of the weight, because the load passing over the bridge keeps near the centre, and moreover the side-rails will prevent the load bearing on the outside balks. The chess, it is true, is laid to distribute pressure, yet it is safe to say that the outside balks have only about half the work of the centre ones; hence each balk should be calculated to bear one-fourth of weight when there are five used. Of course where there is a distributed weight, that is when the weight is spread evenly over the length of the beam or balk, it will stand much more than when it is concentrated at one point; in fact it will bear only half the load when so concentrated that it will bear when distributed. Then again we have to distinguish between a "dead" and a "live" load, for when the load is stationary or (dead) the strain produced is not as great as when the weight is in motion, or (live) the dead being to the live as

1 : 1½. A factor of "safety" is used in construction of military bridges, in general taken as three and may be defined as the fractional part of the breaking weight for balks or supports, which may safely be used for bridge purposes. The following formulae will be useful as giving the safe distributed dead load in hundred weights for rectangular beams, and circular and half circular logs and spars with a taper.

1st.—For rectangular beams

$\frac{BD^2}{L} \times \frac{8}{f}$ in which B and D represent the breadth and depth and L the length of the beam, and f the factor of safety which as before stated is usually taken as 3.

The circular log has about $\frac{6}{10}$ of the strength of a squared beam whose side is equal to the diameter of the log, hence we have

2nd.—For the circular log

$\frac{6}{10} \times \frac{D^3}{L} \times \frac{8}{3}$, D being the diameter of the log.

For half circular logs one-half the strength of the circular.

For spars with a taper we substitute mean diameter in formula (2).

Trestle bridges are useful in shallow streams with hard bottoms and not liable to freshets, as they require but little lumber, are very portable, easily placed and easily constructed with light material; on the contrary they stop navigation and furnish a resting place for drift matter. Trestles may have any number of legs from two to six, and the selection ot the kind depends upon the depth of water and the velocity of the current; the three legged one very preferable in muddy bottoms, it being easy to readjust to the level of the roadway if the roadway rises, or if one trestle sinks more than the other by re-arranging the transoms.

The parts of the three legged trestle are the upright or standard, three ledgers holding the feet at proper distance apart and their height depending of course upon the nature of the bottom, and two cross bearers resting upon two stakes lashed to inner leg or standard for one end of transoms to rest on. In constructing see that

the point where the legs cross is vertically over the centre of the figure of the triangle which forms the base of the trestle, and that the sides of the triangle are not less than three-sevenths and not more than four-sevenths of the point of crossing from the ground. It is best to first lock two legs together with a shear lashing, and afterwards add the third leg.

A two legged trestle consists of two legs or standards, one ledger one transom and two diagonal braces. The legs should incline outward from top to bottom at a slope of $\frac{6}{1}$, and the braces should have a slope of $\frac{20}{1}$.

A four legged trestle is made by joining together two two-legged trestles and adding two ledgers on the spread; the distance of their feet apart should not be less than half their height. The four legged trestle will stand without being steadied but cannot be used on uneven bottom, it is heavy to place in position and like the three legged trestle will collect drift. A two legged trestle is kept upright in the position of the bridge by lashing the balks to the transoms and cross bracing from one trestle to the adjoining one. The trestle may be placed by hand or boat according to the depth of water, or if neither of these methods can be used they must be boomed out in succession. That is by sliding them down by inclined beams and by the use of light spars lashed to the legs, the head of the trestle is raised until it is upright. The trestle may be strengthened in a strong current by passing a strong cable across the stream about the height of the roadway, and after carefully securing it lash the trestle to it or inclined poles may be driven into the bottom and fastened to the trestles, or hurdles may be made and after being lashed to the ledgers loaded with stones. Cribs are so simple as to need no explanation and in sinking them we have simply to weight them as explained for strengthening the trestle in order to sink them if necessary.

Pile bridges will seldom be resorted to; method of constructing same needs no explanation.

We pass now to frame bridges which will be used were no bottom is available as on a chasm or high viaduct, &c. We will concern

ourselves with the single lock and double lock; the first being suitable for spans up to 30 feet and the second up to 45 feet. By spans is meant the horizontal distance between footings, and by footings we mean the places where the feet of the standards are to rest. The footings ought to be 18 inches nearer together on one side than the other for single locks. In making a single or double lock bridge we must first prepare the footings and then lay out on the ground an exact full sized section of the gap to be bridged using pickets and cords. Lay out the standards on the section and mark them at proper positions for transoms and ledgers.

Make one frame on each side of the gap, butts of standards towards the gap, lash the ledgers on top the standard, the transom underneath, a difference of one foot in width between width of transoms will give sufficient splay to the standards. One frame is made 18" wider throughout than the other if a single lock. The diagonal braces are lashed to the standards, two butts and one tip above them and to each other, their backs being placed as nearly as possible at right angles to each other. The footings should be about two feet from the butts of the standards but the nature of the footings may vary this, so prepare footings in such a manner that the frames may be lowered vertically into them and their lower surfaces should be in a plane perpendicular to the direction, the spar frames will rest in when locked.

Everything being ready we attach two fore guys to the top of each frame passing those of the narrow frame under those of the other. Two back guys are also placed on each frame and one foot rope; the back guys and foot rope are passed around a holdfast. The frame is raised and carried forward until it is balanced on the edge of the gap, the butts are then lowered into the footinge by easing off on the foot ropes and guys. The frames are then hauled over by slacking on back guys, the men on the front guys hauling and guiding until the frames are locked. A transom is then hauled out and placed on the fork, two sill pieces laid on bank and the balks laid and then the chess.

A single lock bridge if the footings do not have to be cut in masonry should be completed in about one hour by about 25 men. The

slope of the frames should be not over $\frac{4}{7}$ otherwise the frames might break by buckling, that is by bending sideways. The bottom of the transom should not be less than $\frac{2}{7}$ the span above the line jointing the feet of the frames.

On a double lock bridge the section is marked off on the ground and divided into three equal parts, the frames are made one on each side and of the same width; they are then launched and lowered until a little above their final positions and the back guys made fast. Two beams called distance pieces are hauled out and placed in position inside the standards resting on the transoms; the road transoms are then placed and lashed to the distance pieces and the side frames are lowered until the lock into the longitudinal frames. The longitudinal frame is eighteen inches less in width than the side frames and the distance of the road transoms from each other is equal to $\frac{1}{3}$ of the span and the position on the distance pieces where the road transoms are to rest should be marked accordingly.

In laying the balks or road carriers they are placed parallel to each other, the ends resting on the shore transoms and one or two road transoms, their ends overlapping at transoms the balks of the next bay, and in order to prevent them from pushing the roadway upwards they are lashed together on each side of the transoms where they overlap. The shore transoms are laid at a distance from the bank depending upon the soil, partly buried and secured by pickets driven on each side, the transoms to be a little longer than the breadth of the bridge, and after the balks have been laid in position a plank is set on edge at their ends and dirt banked against it.

For a single lock bridge, 9 feet roadway and 30 feet span we would require

4 standards 7 inches at thinnest end and about 22 feet long.
1 fork transom about 10 inches throughout.
2 transoms 6 inches.
2 ledgers 4 inches.
4 diagonal braces 3 inches.
2 shore transoms 6 inches.
10 road bearers 6 feet.

In a double lock bridge of same span, &c., the distance pieces should be 8 inches.

By a floating bridge is meant one where the piers are composed of buoyant material anchored in position and supporting the roadway.

The site for a bridge should be near main line of communication and the approaches to it good; the bottom should afford good anchorage; the near bank should if possible command the far one and afford cover whilst having the far one open and exposed, avoiding any position with marshy banks; Islands should be utilized, reentering bend best. The advantage of a floating bridge are that the depth of water and nature of river bed need not be considered, drift matter will pass under the piers and cuts may be made and so not obstruct the navigation of the river. In order to avoid swinging of the bridge from side to side the length of the piers of a floating bridge should be double the roadway. Piers may be formed of pontoons, boats, casks or timber rafts, and the construction of bridge should be preceeded by a measurement of the river and section of the bed. Each pier should have available buoyancy sufficient to support the heaviest load which will be brought to bear on one bay of the bridge. The waterway or interval between them should never be less than the width of the piers. Casks bear grounding better than boats. When open boats are used ordinary load should not sink them lower than 1 foot of gunwale. With closed vessels such as casks $\frac{9}{10}$ of the actual may be considered as the available buoyancy. I will not go into the construction of a pontoon bridge as it is explained elsewhere.

A floating bridge may be placed in position by booming out, that is, as the head of the bridge is finished it is pushed out into the stream and material added from the near until the far bank is reached.

Forming up, the reverse of booming out.

By rafting that is each raft of two or more piers is prepared separately on the bank and then placed in position.

By swinging that is completing the whole bridge alongside the bank and then swinging it across the stream.

In boat bridges boats of the same size should be selected to keep roadway level; cargo boats preferable; balks must not rest on gunwales but on central saddles; "beams boxed in each boat raised a little above the gunwales," the saddle resting on rough framework built uy from keelson.

In tidal streams boats should be placed alternately stem and stern and moored at each end. A working party should be told off to keep the bridge in order and to bale the boats. Obstacles should be constructed some distance from the bridge to catch floating substances. The obstacle may consist of a chain or cable stretched across stream, or a boom formed of large logs.

To find the buoyancy of a boat load it with unarmed men until it sinks to one foot of the gunwale. The number of men multiplied by 160 the average weight of an armed man will give available buoyancy in pounds. As before said casks stand grounding better than boats, require no skilled labor, are less liable to sink under fire and require no baling, etc. Large casks are better than small ones and should be carefully sorted, must not leak and the bungs must be secured. Usually seven casks are used and the pier is constructed as follows: The casks are laid in a line bungs uppermost, two gunnels (balks) are placed over them about 6 inches from their ends. Then fasten the sling (2½″ rope) to one end of each gunnel, pass them under the casks, bring up, haul taut and fasten to the other end of the same gunnel. Now take 12 small ropes (1½″) called braces, between each pair of casks, on each side a brace is secured on the sling, is then led around the gunnel, the opposite braces are crossed, pulled taut then brought back to their own side and secured around the gunnel. To do this properly it is necessary to have two more men than double the number of casks. The road balks should rest on both gunnels of each pier, the piers being kept at proper intervals by two tie balks lashed to both gunnels of each pier.

A safe buoyancy in pounds of a cask may be determined by multiplying the contents in gallons by ten. Actual buoyancy from formula $5\ c^2 l - W$, c being average circumference l length in feet and W weight of cask in pounds.

Available or safe buoyancy (which we have said in this case amounts to $\frac{9}{10}$ of actual buoyancy) is that part of the actual buoyancy of a floating body which may safely be used in a bridge.

Rafts of casks may be used also for placing trestles or piles for conveying guns or heavy stores across a river when no bridge can be made or for a flying bridge when no boat is available.

We will use rafts of timber when other floating piers cannot be formed when current is not over 3 miles per hour, and when timber is plentiful close at hand and can be floated into position. They have the merit of requiring no skilled labor, cannot be sunk by hostile fire and last a long time; their drawbacks—little buoyancy, they are clumsy, obstruct waterway and require a considerable time.

The lightest wood obtainable makes the best raft. In order to find flotation of log in pounds multiply the cubic contents by the difference between the weight and that of a cubic foot of water, viz: 62½ pounds. For example suppose one cubic foot of the log weighed 30 pounds, and if the log contained 60 cubic feet the actual flotation would be $60 \times (62\frac{1}{2} - 30)$. Of this only $\frac{5}{6}$ can be safely used and gives available buoyancy.

The cubic contents of a squared log is obtained of course by multiplying the sectional area by length in feet, that of an unsquared one by multiplying the square of $\frac{1}{5}$ of the mean girth in feet by twice the length in feet.

The logs are laid side by side thick end and thin end alternating, secured by clamps or ropes and balkes spiked to each log.

Saddles are then laid on the balks parallel to the logs to support roadway bearers.

The piers of all floating bridges must have sufficient buoyancy to support with safety the greatest weight that will be brought upon them, and the road bearers must be strong enough to bear the greatest stress that will come on them. The maximum weight to be borne by any pier is found by adding the maximum weight of passing bodies (troops. wagons, &c.,) that can be placed the length of one bay, to the weight of the superstrrcture of the bay. By the availabe buoyancy of one bay is meant the result obtained by subtracting the weight of the superstructure of the bay from the available buoyancy

of the pier. The average weight of a soldier in arms is about 160 pounds.

The reason why artillery strains a bridge more than cavalry or infantry are, 1st that the weight is not well distributed, and 2nd the weight of the gun and carriage is fixed, whereas the weight allowed for infantry will probably be in excess of the reality on account of the men breaking step and so opening out. The greatest weight that will be brought on the bridge is by infantry when crowded by check and in order to estimate this find number of square feet in one bay, then allow 100 or 133 pounds per square foot according as the infantry are in marching order or unarmed.

The constructive weight of the superstructure of a 9 foot roadway is 80 pounds per linear foot.

A flying bridge is one in which the action of the current is made to move a boat or raft across the stream by acting obliquely against the side. A long narrow boat with deep vertical sides like a canal boat is best, since it presents more surface to the current to act upon and the bow offers less resistance to the required movement. The side of the boat should make an angle of about 55° with the current.

There are three methods of working a flying bridge

1st by a suspension cable.
2nd by a swing cable.
3rd by a warp.

Should the current slacken near the bank a line from the landing point should be buoyed in the track of the bridge to haul it in and out.

Straight reaches are best for a flying bridge because the current is more regular. A velocity of current of at least two miles an hour is required.

In any swinging cable the length of cable should be from 1½ to 2 times the breadth of the river and the weight of the boat should be much greater than that of the cable.

THE STRINGER BRIDGE.

If the span be 25 or under, the abutments intact, and timber of sufficient length and strength exists in the vicinity the construction

of an improvised stringer bridge will be easily and readily accomplished.

Labor will be abundant and axes and perhaps an auger all the tools required.

The work to be performed

1st Cutting the timber
2nd Carrying the timber
3rd Placing the stringers
4th Laying the flooring.

Cutting the timber.—Put as many men to work as can be conveniently used. Select your timber so that any error as to question of strength will be without any doubt be on the safe side; six stringers are required. Two axemen needed to each stringer.

Fifty flooring poles 6 in. diameter and 12 feet long are also required; these can be cut after stringers, and altogether the work in the wood should not take more than 15 minutes.

Carrying the timber.—Men enough should be assigned to carry all the timber in one trip. The stringers in order to have a bearing of two feet on each side will be 29 feet long and assuming them to be 10 inches in diameter will weigh 643 pounds each. This is a good load for ten men with handspikes, therefore 60 men will be needed to carry the stringers.

The flooring poles as above will weigh 97 pounds a load for two men or 25 men for the poles; altogether therefore 85 men for carrying. The weights are calculated upon a basis of 41 pounds to cubic foot, as taken from tables of strength of materials. The men as soon as they have deposited the load must be required to stand aside and not allowed to crowd about the work.

Placing the stringers.—While the material is being prepared, the officer in charge ascertains the depth of the chasm and makes preparations to jump the stringers across the span. For this purpose he requires two jumping poles strong enough to bear the weight of the stringer and a little longer than the hypothenuse of a right angled triangle, the base and perpendicular of which are respectively three-fourths the width and depth of the chasm. The weight of

the stringer being 643 pounds the weight to be supported by each pole will be 322 pounds.

Assuming that 20 feet is the length of the poles as determined by solving the right angled triangle above referred to we will obtain the diameter by the formula $\sqrt{L^2 W \times 1.7 e} = 4''.36$ in which L length of pole, W breaking weight and e unit of resistance, taken from the tables. Taking 4½ inches as the diameter of the jumping poles at the small end, a large allowance for safety, the weight of the poles will be 122 pounds each, an easy load for two men. These should be at the bridge at the same time as the first stringer.

When the first stringer arrives, it is temporarily laid on the abutment as a wall plate and chocked. The second and third are slid out over the chasm a little more than one-fourth of their length so as to make a footway for that distance; one of the jumping poles is then slid out butt end first, until it nearly balances on the wall plate stringer. The bight of a rope is then passed around it, a little in advance of its centre of gravity by means of which a man on the footway supports the butt, while the pole is being slipped forward, until it reaches the place where it ought to rest. While this is being done the ends of the stringers which constitute the footway are held down.

The second jumping pole is put in position by similar means on the other side of the footway. The two stringers are then drawn back, the jumping poles are crossed and lashed two feet above the level of the abutment and a guy rope is attached long enough to reach across the stream.

A stringer is then laid into the crutch of the jumping poles and pushed forward until it nearly balances. It is then permitted to rest in the crutch and pushed forward carrying the jumping poles along with it, until its end is over the opposite abutment. Four men now cross over on the log, steadying themselves on the guy rope—held fast for that purpose—lift the stringer out of the angle of the jumping poles and together with others on the opposite abutment roll it to one side and place it.

As soon as the stringer is clear of the jumping poles, they are pulled back by the guy rope, another stringer is jumped across and

so on, until all are across and placed. Stringers should be laid about two feet apart from center to center and with the natural bend of the stick up.

Laying the flooring.—This is done after the style of the corduroy road and should not take more than five minutes. The column can now pass on, while the bridge is being finished by pinning on a ribbon of poles to hold down the ends of the flooring and erecting handrails if such be deemed necessary, It is always well to cover the roadway of such a bridge with straw to lessen the jolting of carriages.

The delay on account of the bridge should not have exceeded one hour.

THE SCARFED STRINGER BRIDGE.

When stringers of sufficient length to reach across the chasm cannot be obtained, or where they are to heavy for convenient handling, or jumping across, resort may be had to the scarfed stringer bridge. It is assumed as in the last case that the bridge is to replace one destroyed, that the abutments are intact and both accessible and that material can be procured on both sides.

For a span of 25 feet six stringers 25 feet long and 10 inches in diameter are brought to each abutment, their smaller ends prepared for scarfing—that is, hewed on their upper side for a distance of 18 inches—and then pushed out from the abutment a distance of ten feet. These are laid 2 feet apart from center to center, their shore ends securely anchored down and loaded, by laying a corduroy road of heavy logs gradually diminishing in size, from the shore ends to the edge of the abutment. The work on both sides proceeds simultaneously. Six short stringers 8 feet long and 10 inches in diameter, are now brought forward 3 on each side, prepared at the ends for scarfing—that is in this case hewed on both sides—a distance of 18 inches, passed across the gap, laid accurately on the long stringers, two 3 inch auger holes bored at each end through both stringers, hardwood pins driven and wedged at the ends, the flooring poles laid and the bridge is finished. The flooring poles on the bridge will be light, those on the short stringers 5 inches in diameter.

The scarfed stringer bridge may be applied to a 30 foot span, by slipping the long stringers out a distance of 12 feet, securely anchoring the shore ends and loading them as before, and bracing each long stringer by a piece resting in a niche of the abutment just above the water and driven into a notch on the under side and near the end of the stringer. The short stringers in this case should be 9 feet long. They are prepared, placed and secured as in the last case and the bridge is finished by laying the flooring as before.

THE SIX LEGGED TRESTLE.

This trestle can be made of round logs by soldier labor, and will adapt itself to almost any irregularity of bottom. It is composed of:

4 Vertical legs, 6 inches in diameter.
2 Bracing legs, 6 inches in diameter.
1 Cap or girder 8 inches in diameter.
2 Foot pieces 8 inches in diameter and 3 feet long.
10 White oak pins, 3 inches in diameter.

There are no tools required, except those usually carried with troops, namely, axes and augers, and some rope.

For raising the trestles, two sliding beams 8 inches in diameter and at least twice the length of the span, four short rollers—sections of logs—two 12 inches in diameter and two 6 inches will be required; these can be procured from the woods.

Making the trestle.—Soundings having been taken along each side of the supposed bridge the lengths of the several trestles having been determined, and material procured, the men proceed to make the first trestle.

Selecting some level spot near the water from which the prepared trestle can be readily launched, a framing platform is constructed. This platform consists of two logs, parallel to each other and the width of the bridge apart, laid with an inclination of about 30° towards the water to facilitate the launching of the finished trestle. The upper face of the platform should be hewed. These are designated right and left with reference to the trestle legs as they lie on the platform, to minimize the chances of error in constructing trestles with unequal legs.

Having received instruction, as to the lengths of the right and left legs of the first trestle, the makers lay logs of the requisite length on the proper sides of the platform. The cap piece is laid across at the height of the roadway, the foot pieces across the feet of the trestles. The other two vertical legs are then laid on the top, resting on the cap and foot pieces, and four auger men bore through the three logs at each corner. Pins are then driven and if necessary wedged, and the bracing legs pinned to the foot pieces. The trestle is then launched and towed or poled into position for hoisting.

Meantime preparations for hoisting have been going on, the sliding beams have been advanced, one on each side of the road until their front ends are over the position of the first trestle, the large roller in front a very little in advance of the center of gravity of the beam, the small roller in rear.

If there be much current some provision should be made to hold the trestle for the few seconds necessary to adjust the slings and raise it into a standing position.

The trestle is brought abreast of the bridge head, the cap towards the bridge, and as near its proper position as practicable.

Raising the trestle.—The sliding beams are lowered by raising their ends until they nearly touch the water; short slings are passed around the ends of the sliding beams. The trestle is then raised slowly, by lowering the rear ends of the sliding beams, until it hangs directly over its place. It is then allowed to drop into position by raising the rear ends of the sliding beams, the side stringers are slipped across the span, and secured, the bracing legs are driven into place and pinned, short pieces are spiked or pinned across the vertical legs under the end of the cap piece as supports and the trestle is placed and finished.

Laying the stringers and flooring as before described.

Note.—If on account of the length of the sling used, it be found impossible at the first lift to raise the trestle's feet off the bottom, let it rest and shorten the sling, or if necessary place the end of the sliding beams under the trestle cap for a fresh lift.

The following methods used in the west by troops for crossing streams may be of interest.

1st By filling in the bed of a stream or ravine with logs, covering these with a layer of brush and in turn covering the brush with a thick layer of sod or earth. It is very seldom that time can be allowed for carrying this structure high enough and consequently the approaches must be cut quite deep. It is a matter of experience that teamsters while going down the incline will almost always allow their teams to go down at full speed, cutting deep in the causeway and thereby requiring constant repairs.

The brush used may be sage, willow and young cottonwood. The sage is by far the most easily handled and the most enduring. Logs to serve as side rails should be laid, and the roadway should be at least 15 feet wide.

The axis of the approaches and the crossing should be in the same plane, perpendicular lo the axis of the stream. This would seem a trivial remark, but it was frequently observed, that the men unless closely watched, would unconsciously deviate from the proper direction and the crossing would be oblique to the stream.

2d. By making a cribwork of spare wagon tongues, and laying others covered with sod to form the roadway. The army wagon pole is 10.7 feet long. (See Fig. 2).

3d. By employing the bull ropes or fifth chains as suspension cables and laying at the bottom of the catenary three or four wagon tongues to act as a kind of girder. The flooring is laid with other wagon tongues and the whole covered with sod. The prevent swaying lariats may be fastened to the ropes and anchored to the shore. (See fig. 3). This course is of course, limited to timbered streams and to those which are a little less in width than twice the length of a wagon tongue or 21 feet.

4th. By employing floating piers, each consisting of a wagon body placed over the number of empty kegs that can be confined within the body. The roadway as before is formed of wagon tongues. Lariats can be used as anchoring cables for the piers.

To determine what weight approximately will be borne by such a pier the following formulae will be used:

$$W = (v \times 62.5 \text{ pds.}) - K$$

$$\frac{a+b}{2} = d \quad v = \frac{3.1416}{4} \times l = 0.7854\, l \left(\frac{a+b}{2}\right)^2$$

in which

W = weight in pounds which a keg will bear.
K = weight in pounds of the keg.
v = volume of the keg in cubic feet.
l = length of the keg.
a = diameter at bung.
b = diameter at end.
d = mean diameter.

The values which follow were determined for the 10 gallon keg by Lieut. Nave, 7th Cavalry, and Private Goslin, Engineer Battalion.

$K = 21$ pds. $\frac{a+b}{2} = \frac{1.372+1.02}{2} = 1.196.$

$l = 1.708$ feet

$a = 1.372$ feet $v = 0.7854 \left(\frac{a+b}{2}\right)^2 = 0.7854 \times 1.708 \times (1.196)^2$

$b = 1.02$ feet $v = 1.918$

$W = (1.918 \times 62.5 \text{ pds.}) - 21 \text{ pds.} = 119.88 \text{ pds.} - 21 \text{ pds.} = 98.88 \text{ pds.}$

That is, each keg is capable of sustaining a weight of 98.88 pounds.

The interior dimensions of the 6 mule army wagon body are as follows: depth 2 feet, length 10 feet, width 3.58 feet.

Fourteen 10-gallon kegs will about fill a wagon body of the above dimensions and hence each set of kegs will virtually sustain a weight of fourteen times 98.88 pounds or 1384.32 pounds. Subtracting from this the average weight of the body (423 pounds) we shall have 961.32 pounds as the weight which can be borne by each pier.

The dimensions of the wagon tongue are as follows:

Length of tongue = 10.7 feet.
Breadth at point = B' = 2.5 inches.
Depth at point = D' = 2.5 inches.
Breadth at butt = B'' = 3.88 inches.
Depth at butt = D'' = 2.75 inches.
Mean breadth = B' = 3.19 inches.
Mean depth = D' = 2.625 inches.

Supposing the tongues not to lap on the piers, we shall have for the length of tongue between supports

$$L = 7.12.$$

Substituting these values in the formula for a beam resting upon two supports or

$$W = \frac{6kBD^2}{L}$$

we shall have

$$W = \frac{319 \times (2.625)^2}{712 \times 12} \times 1200$$

or

$$W = 308.8$$

and dividing by 4 the factor of safety we have

$$W = 77.$$

The average weight of the army wagon is 1800 pounds and assuming the weight of a mule as 1000 pounds we shall have 7800 pounds as the weight of the wagon and mule team. Assuming, now, the average weight of load to be 4000 pounds we shall have as the weight on the bridge 11,800 pounds.

The total length of bridge occupied by wagon and team is 49 feet and consequently the load per running foot is 241 pounds, nearly. Referring to the breaking weight of the tongue, we see that four tongues laid as balks are sufficient; 40 tongues will be required for flooring if laid close. There will then be in all 44 tongues, weighing 28 pounds each. In other words each bay exclusive of the piers will weigh 1232 pounds or 115.1 pounds per running foot. We have as the weight of 49 feet of bridge with load 11,800 pounds plus 115.1 pounds $\times$ 49 or 17440 pounds, nearly.

We have seen that each pier will support 961.32 pounds, and five piers would support but 4806.6 pounds or only about one-fourth of the weight upon the bridge in crossing a loaded team. So it would be necessary to increase the number of sets of kegs for each pier, or else decrease during the time of crossing the number of mules in each team, and the weight of the load.

A similar bridge can be constructed by using simply the kegs, lashed together for piers, but the other method is preferable, as the wagon body keeps the kegs together, besides furnishing a level bed on which to lay the balks.

5th. By felling four trees, which, with the butts resting on the banks will by crossing each other two and two, form supports for a girder and then laying a flooring. They should either be spiked or lashed together where they cross. (See fig. 4.)

6th. By forming rude trestles, which may be either simply notched, or what is better spiked with lariat pins (See fig. 5). The girder timbers can be squared, off on the upper side and the stringers be notched so as to hold better. The main pieces of the legs may be anchored to the shore by lariats.

A tripod trestle bridge can be formed of simple tripods connected at the bottom by braces. A bar is lashed or pinned across two legs of the tripod, and on this rests the cap-piece as in the figure. (See fig. 6.)

7th. By various combinations of saplings forming what are termed single or double lever bridges.

A single lever bridge is composed of two frames which lock into each other (See fig. 7).

A full sized section of the stream or gap should be first traced on the ground. The line representing the breadth should be bisected. Two standards should then be laid down on the section and on them marked the places where the main transoms, the fork transoms and the ledger will come. The frames should then be constructed. These distances should be between standards at the transom 9′ 6″ and at the ledger 10′ 6″. In the other frame the distances should be 11′ and 12′ respectively. As the frame lies on the ground with its butts towards the stream the transom should be under and the ledger above the standards.

The diagonal dimensions of the frames are measured to ascertain whether the positions of the pieces of the latter have not changed. Of the diagonals, one is altogether above the frame, the other has

its butt over and its top under. The diagonals are lashed to each other where they cross and also to the standards.

The frames are raised and lowered into their positions by means of foot and guy ropes. The pickets for the foot ropes are driven into the ground about two paces from the edge of the bank and four paces on each side from the center of the frame. The foot ropes are attached to the butts and passed twice around the pickets. The pickets for the guy ropes are driven in about twenty paces from the bank and ten paces from the central line. The fore and back guys are fastened to the tips, the ends of the fore guys thrown across the stream and those of the back guys passed around twice their respective pickets. The frames are then raised by hand and carried to the edge. The butts are then gradually lowered into position, one frame being hauled over until it is a little beyond the perpendicular, in which position it is secured by fastening the back guys to their pickets. The other frame is dealt with in a similar manner. Both frames are then lowered until they interlock. A spar is laid across the fork formed by the crossing of the standards to serve as a support to the road beams.

The roadway is composed of balks lashed to each other, and covered with planks, spiked or rack-lashed down, or by fascines covered with loose brushwood, earth or heather. The ends of the balks should be attached to a beam or stout spar half buried in the ground and picketed down, its direction being perpendicular to the length of the bridge. It is desirable to place rails or breast lines at the edges of the bridge. At each transom the road beams should be all tips or all butts, and the ends of each pair should be lashed together. It must be noted that the frames should not make a greater with each other than 120°.

A double lever bridge is formed in a manner similar to that in which a single lever bridge is constructed, with the exception that the frames do not cross each other but are connected by means of a second frame which has no diagonals. (See fig. 8).

Double lever lever bridges are suited for openings of 40 feet. Even openings of 60 feet have been spanned by a double lever bridge.

Another combination can be made by forming a lever truss bridge. The frames are made as in the case just cited, but an extra support is given to the roadway by the rope at the center. (See fig. 9).

THE MAGNETIC COMPASS.

The appliances necessary for sketching with a magnetic compass in plane table fashion besides the compass are:

1. Any flat surface about one foot square such as a board.
2. A straight edged piece of wood about nine inches long.
3. A clinometer to measure slopes and gradients.

The principle upon which the compass is constructed is simply that of the pattern used in the Cavalry sketching case, described above.

In the Cavalry sketching case there is a "working meridian" line across the glass, which is capable of being set at any required angle, with the "line of direction" (or general line of advance) by revolving the compass in the graduated ring encircling it. The direction of this line is indicated on the board by an arrow. The meridian being thus abjusted, all that is required is to turn the board until the magnetic needle coincides with it, when the "line of direction" on the board will indicate the line of advance to be followed (see fig. 5). If the compass in the " Cavalry sketching case" as shown in fig. 2 be compared with the magnetic compass in fig. 3, it will be seen that this principle is carried out.

The "meridian line" of the sketching case is replaced by an index bar in the compass, whilst the "line of direction" is shown by the slit in the lid by day and by the white luminous line in the lid by night.

In figs. 2 and 3 both instruments are set for an advance on a bearing of 45° or NE.

In order to provide a simple and effective method of adjusting the index-bar of the compass to any required bearing, a ring graduated into degrees and into points, is attached to the outside of the compass. The compass is "set" to any particular bearing by turning the index-bar until the end of it is exactly above the graduation on the ring.

It may be mentioned here that the graduation on the ring is necessarily made in a reverse direction to the ordinary manner. Thus North is marked S. or 180°, East, W. or 270°, South, N. or 360° and West, E. or 90°.

This sounds a little confusing, but in practice is not in the least so, for the mechanical process by which the index is set to the required bearing engraved outside the compass-box does not in any way interfere with the general working or utility of the compass. Since it is of the most vital importance that the index should on no account be liable to be shifted, a clamping arrangement is provided which enables the index-bar to be rigidly set at any required bearing.

For the sake of obtaining larger and clearer figures on the external graduated ring, as also on the compass-card the graduations 10°, 20°, 30°, &c., are simply marked 1, 2, 3, &c.

The external ring is graduated to 5° on its upper edge, and to "half points" on the lower edge; the points are indicated by long graduations and the half points by short ones. Let us suppose now, that it is required to set the compass for a march in the north-easterly direction, or in other words, on a bearing of 45°. To do this, the milled ring holding the glass is revolved until the end of the index line coincides with the graduation midway between the figures 4 and 5, that is at 45° or NE. A turn in the clamping screw will ensure it from slipping round.

The compass is now ready for use (fig. 3).

To ascertain the direction of the line of advance (NE.) place the compass on the palm of the left hand with the lid opened wide and laid flat back; hold the left hand in front of the center of the body, and release the lockstop, so as to allow the card to drop upon its pivot and oscillate. Now check the oscillation, if too rapid, by a gentle pressure upon the checkstop or by simply slightly tilting the compass in the hand. When the card steadies down note the position of the index-bar, and gently turn the whole body, with the hand held steadily in front of it, until the North point on the card coincides with the index-bar. When it does, the luminous white line in the lid will point like a finger in front of the observer in a direction bearing 45° or NE.

The essence of the whole system is that by an infallible mechanical process, the direction of any particular point of the compass can be ascertained on the darkest night *without reading the compass-card*, since as long as the index-bar remains where it has been set and clamped and the magnetic north point be made to coincide with it, the line in the lid *must* point in the required direction.

The movable index-bar, combined with the facility of clamping it in any desired position comes in exceedingly useful in many ways. Thus, when a careful study of any existing map, has to be made on the ground, it can be at once truly "set" as follows:

Clamp the index-bar at the known local variation, and lay the compass with the notch in the handle and slit in the lid along the true North and South edge of the map. The latter is then turned until the magnetic north point is seen to coincide with the index-bar, when it is plain that the map will be correctly placed for identifying any required points.

CONVENTIONAL SIGNS. PLATE I.

1 Triangulation point.
2 Plane table point.
3 Comm'n surv'y point.
4 Signal tower.
5 Stone landmark.
6 Wooden landmark.
7 Mound landmark.
8 Tree landmark.
9 Monument.
10 County boundary.
11 State boundary.
12 Rail or "worm" fence.
13 Picket fence.
14 Board fence.
15 Stone wall with coping.
16 Stone wall, rough.
17 Hedge.
18 Path, foot.
19 Path, mounted.
20 Road, undefined.
21 Road, minor.
22 Road, main.
23 Road, paved.
24 Railroad, single track.
25 " double track.
26 Telegraph
27 Embankment.
28 Cutting.
29 Tunnel.
30 Building, wooden.
31 Building, masonry.
32 Church.
33 Light house.
34 Windmill.
35 Settlement.
36 Village.
37 Town.
38 City.
39 Well.
40 Spring.
41 Pond.
42 Marsh, fresh.
43 Marsh, salt.
44 Brook.
45 Creek.
46 Practicable for all arms.
47 Practicable for Infantry and Cavalry.
48 Impracticable.
49 River.
50 High and low water.
51 Dam.
52 Falls.
53 Canal with locks.
54 Aqueduct.
55 Head of navigation.
56 Buoy.
57 Rocks, bare.
58 " sometimes bare.
59 " sunken.
60 " dangerous.
61 " position uncertain.
62 Bar.
63 Shoal.
64 Fog bell.
65 Light ship.
66 Anchorage.
67 Wreck.
68 Surf.
69 Direction of current.
70 Ford, foot.
71 Ford, wagon.
72 Bridge, foot.
73 Bridge, wooden.
74 Bridge, draw.
75 Bridge, truss.
76 Bridge, stone.
77 Bridge, pontoon.
78 Bridge, suspension.
79 Ferry, row boat.
80 Ferry, steam.
81 Ferry, rope.
82 Ferry, flying.

TOPOGRAPHICAL SIGNS. PLATE II. OLD MAPS.

1 Mill, water power.
2 Mill, steam power.
3 Saw mill.
4 Ship mill.
5 Powder mill.
6 Cotton mill.
7 Woolen factory.
8 Sugar factory.
9 Silk factory.
10 Indigo factory.
11 Iron works.
12 Glass works.
13 Brick kiln.
14 Lime kiln.
15 Rope walk.
16 Quarry.
17 Chapel and Church.
18 Custom house.
19 Post office.
20 Hotel.
21 Inn.
22 Railroad station.
23 Telegraph station.
24 Mineral spring.
25 Gate, turnstile.
26 Weir.
27 Buoys.
28 Buoys, mooring.
29 Sentinels.
30 Videttes.
31 Indians, with fire-arms.
32 Indians, without fire-arms.
33 Gold.
34 Silver.
35 Copper.
36 Mercury.
37 Lead.
38 Tin.
39 Iron.
40 Coal.

14 DAY USE
RETURN TO DESK FROM WHICH BORROWED

LOAN DEPT.

This book is due on the last date stamped below, or on the date to which renewed.
Renewed books are subject to immediate recall.

21 Apr'62DS

REC'D LD
APR 10 1962

LIBRARY USE

REC'D LD
APR 18 1962

14Apr'65LD

REC'D LD
APR 6 '65-2 PM

JUN 15 2004

SENT ON ILL
OCT 12 2005
U.C. BERKELEY

LD 21A-50m-3,'62
(C7097s10)476B

General Library
University of California